Proposal for Fuel Cell and Other Clean-fuel Powered Ferries for Pearl Harbor (USS Arizona Memorial)

National Defense Industrial Association (NDIA)

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USS ARIZONA MEMORIAL

CLEAN FUEL GRANT

- Ferry transports visitors to and from the USS ARIZONA Memorial
- Currently 2 ferries in operation normally per day
- Aging ferries under constant maintenance
- The State of Hawaii's DOT to receive $4,846,159 for design and construction of two new, clean-fuel technology, ferries

CONSIDERATIONS

- Type of hull
- Use existing or new design
- Fuel storage, accessibility, and infrastructure
- Emission benefits
- Maintenance requirements
- Propulsion module
- Power technology

POWER TECHNOLOGY

- Biomass
- Propane
- Natural Gas
- Solar/Wind
- Fuel Cells

BIOMASS/BIODIESEL

- Derived from trees, grains, vegetable oils, agricultural residues, and sugar cane
- Converted to fuels through either combustion, distillation, gasification, fermentation, & pyrolysis
- Can be integrated into existing petroleum infrastructure easily and safely
- No engine modifications required
- Energy content similar to standard diesels
- Ferry test results: low PM, slightly lower CO but high NOx

PROPANE

- Similar energy content as gasoline
- Costs 20 – 30% less than gasoline
- Refueling sites cost about $100,000
- Propane engines are in production by major manufactures.
- Proven track record and is reliable
- Would cut pollution emissions by about one half.
- Cost depends upon location and demand
- No test of propane boat, may be due to safety risks

NATURAL GAS

- Proven technology for land based and marine vessels
- Since 1982 at least 10 natural gas powered ships built worldwide, half of them ferries.
- Tested in British Columbia, Hampton Roads, San Francisco and internationally
- Natural gas prices depend on location, time of year and demand
- Currently, a good source of natural gas does not exist in Hawaii

NATURAL GAS FERRIES

MV KLATAWA has operated on the waters of BC since 1985

The Norwegian ferry GLUTRA

The Osprey operates in British Co

NATURAL GAS FERRIES

Name	Location	Service	Fuel	Year
Accolade II	Adelaide, Australia	Bulk Carrier	CNG dual fuel	1982
Klatawa	British Columbia, Canada	Car/Passenger Ferry	CNG dual fuel	1985
Kulleet	British Columbia, Canada	Car/Passenger Ferry	CNG dual fuel	1988
Unknown	Amsterdam, Netherlands	Canal Boat	CNG dual fuel	1994
Unknown	St. Petersburg, Russia	Tourist Boat	CNG dual fuel	1994
Various	San Antonio, TX	Tourist Boat	CNG	1995
James C. Echols	Norfolk, VA	Passenger Ferry	CNG	1996
Unknown	Moscow, Russia	Tourist Boat	CNG dual fuel	1999
Osprey	British Columbia, Canada	Car/Passenger Ferry	CNG dual fuel	2000
Glutra	Molde, Norway	Car/Passenger Ferry	LNG dual fuel	2000

SOURCE: MARAD (NMREC)

SOLAR/WIND

- At least two large operating commercial ferries and numerous smaller ones worldwide
- Very clean technology, however a high cost alternative

The Australian MARJORIE K is a non-polluting ferry powered by wind and sun

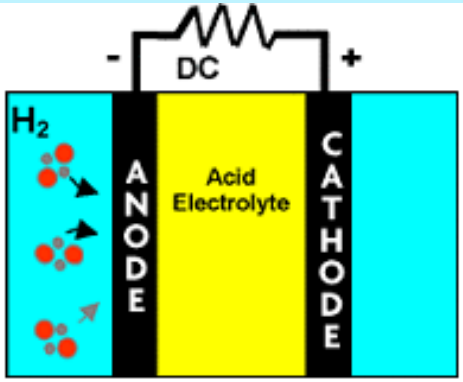
FUEL CELLS

- A technology of interest for the U.S. government because of it's potential
- The federal government has endorsed or funded several hydrogen fuel cell programs
- Received Presidential attention
  - $1.2Billion R&D spending over 5 years

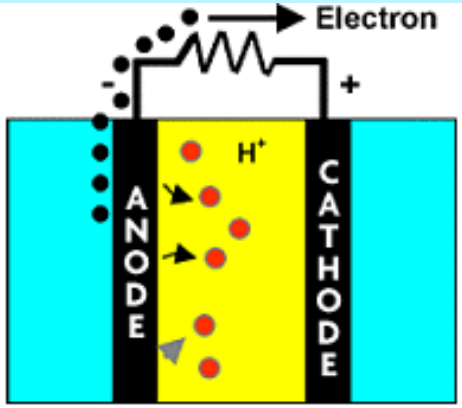
FUEL CELLS - HISTORY

- 1830 – 1890:
  - fuel cells conceived and developed
- 1900 – 1950:
  - Alkaline Fuel Cell created
  - Fuel cell powered vehicle tested
- 1960 – Present:
  - NASA becomes involved in fuel cell research
  - Fuel cell powered vehicles developed
  - U.S. Federal government endorses/funds projects
  - President Bush’s Fuel Cell Plan

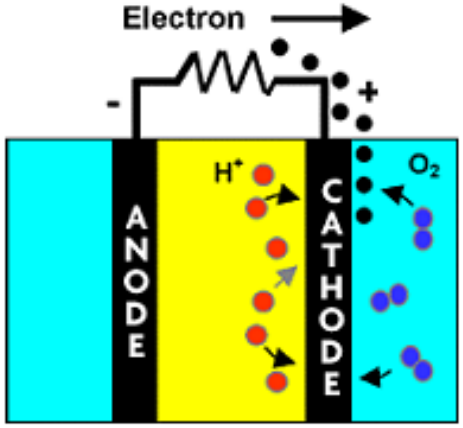
HOW FUEL CELLS WORK



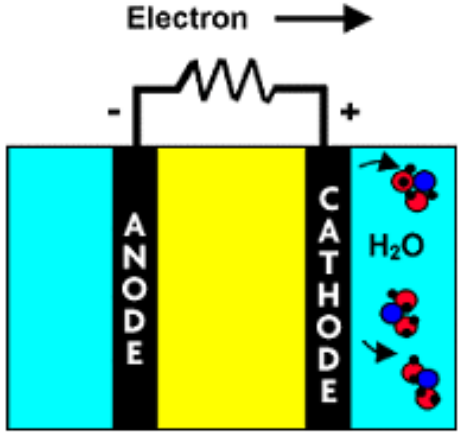
1. Hydrogen gas flows over the anode.



2. Electrons are stripped from the hydrogen and flowthrough the anode to the external circuit.



3. Hydrogen ions move through electrolyte to cathode. Oxygen is introduced to the cathode.



4. Hydrogen ions, electrons, and oxygen combine to form water vapor. (Diagram: U.S. Department of Defense)

FUEL CELL CHARECTERISTICS

	Alkali	Proton Exchange Membrane	Phosphoric Acid	Molten Carbonate	Solid Oxide	Direct Alcohol
Applications	space	Transporta-tion and stationary (small)	Transporta-tion	electric utility, industrial, and military	Ideal when fuel is sulfur rich eg. coal	does not run on H2 Used in laptops, PDAs, cars, etc.
Pros	high efficiency	good efficiency, durable	more tolerant of impurities than PEMFCs	lower catalyst cost, high efficiency, not sensitive to CO or CO2	can tolerate sulfur impurities otherwise identical to MCFC	easier to store and transport. More energy dense then H2
Cons	extremely sensitive to CO2	high cost	less powerful than other FC of same size and weight	shorter cell life	heat shielding, safety issues	low efficiency, safety concerns

SUCCESS STORIES UNITED STATES

- Hydrogen Future Act of 1996
- More than $1 Billion spent on research
- Mainly land based vehicles
- Investment in Ferries: Treasure Island (Water Transit Authority), Pearl Harbor
- Navy developing Ship Service Fuel Cell Generator

SUCCESS STORIES INTERNATIONALLY

- Canada: DND developing an air independent fuel cell propulsion system for use in submarines
- Iceland: 2500 fishing vessels to be converted to run on hydrogen
- Germany: 22 passenger boat developed
- Germany: shipbuilder working with Swedish, Danish, Norwegian navies to develop a new generation of submarines employing FC
- Switzerland/Finland: small boats developed

SUMMARY

	Diesel	Biomass	Propane	Natural Gas	Solar/ wind	Fuel cells
Emissions	Status quo	Less	Less	Less	Clean	Clean
Infrastructure	Good	Limited	Good	Poor	Limited	Limited
Operating Ships/Boats	Yes	No	No	Yes	Yes	Yes
Operating Ferries	Yes	No	No	Yes	Yes	No
Cost	Low	Low	Medium	Medium	High	High

- *Solar/Wind and Fuel Cells……the cleaner alternative*